OCCURRENCE AND MANAGEMENT OF HERBICIDE RESISTANT PALMER AMARANTH IN ARIZONA

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Abstract

Glyphosate resistant Palmer amaranth was first discovered following a control failure in a Buckeye, AZ cotton field in July 2012. Subsequent greenhouse experiments using seed collected from the Buckeye field verified this population was highly resistant to glyphosate (50X resistance) and also resistant to Staple herbicide (4X resistance). A population of Palmer amaranth in San Tan Valley, AZ was found to be moderately resistant to Raptor and Staple but susceptible to glyphosate. Palmer amaranth plants in Marana, AZ escaped three applications glyphosate at the maximum labelled rate. The range of glyphosate symptoms expressed by escaped plant indicated the development of resistance in this population. Two other locations in Arizona, Red Rock and Pearce, AZ also have populations of Palmer amaranth that escaped glyphosate treatment but more seed collections and greenhouse experiments are needed to confirm resistance. Field studies on fallow cotton beds with Prowl H_2O (2 pt./A), Dual Magnum (1.33 pt./A), Caparol 4L (2.4 pt./A) and Diuron 80 WDG (1 lb/A) found that these herbicides were highly effective in suppressing Palmer amaranth germination, emergence and growth 21 DAT. Thus, the use of preemergence herbicides can be an effective way to diversify herbicide mechanisms of action used in Arizona cotton fields.

Introduction

Glyphosate resistant Palmer amaranth was first discovered following a control failure in a Buckeye, AZ cotton field in July 2012. Subsequent greenhouse experiments using seed collected from the Buckeye field verified this population was highly resistant to glyphosate (McCloskey and Brown, 2013). In 2013 and 2014, several geographically separated populations also appeared to become herbicide resistant and seed was collected from these areas, from additional locations in Buckeye, AZ and from other areas in Arizona where there were no reports of herbicide resistant Palmer amaranth. Greenhouse experiments were initiated to begin characterizing the herbicide response of the populations represented in the seed collections. Experiments were also conducted in fallow fields to investigate management of herbicide resistant Palmer amaranth populations. This paper presents the results of some of these 2013 and 2014 experiments.

Materials and Methods

Palmer amaranth seed were collected from mature female plants in several locations in Buckeye, AZ and in San Tan Valley northwest of Florence, AZ, In addition, the response of Palmer amaranth to field applications of glyphosate were observed in Red Rock, Marana and Pearce, AZ. Seed was also collected from a known glyphosate susceptible Palmer Amaranth population growing near Sahuarita, AZ to facilitate comparison of susceptible and putative glyphosate resistant biotypes in the greenhouse. For the greenhouse experiments, seed (several per pot) were planted in an artificial soil mix in 4 inch pots. After emergence, plants were thinned, fertilized and irrigated as needed. Palmer amaranth plants were grown to the 4 (mostly) to 6 true leaf growth stage for experiments. The herbicide treatments were sprayed using a three nozzle boom (XR8001VS nozzles spaced 20 inches apart) and CO_2 pressurized backpack sprayer calibrated to deliver 9.95 GPA at 25 PSI and 2.5 MPH. The formulation of glyphosate used was Aquamaster (4 lb ae glyphosate/gallon) because it did not contain surfactant. A nonionic surfactant, Activator 90, was added to all spray solutions at 0.5% v/v. Plant responses to glyphosate were monitored for 1 to 5 weeks after spraying. Phytotoxicity was visually estimated using a 10 point scale (0 indicating no effect and 10 indicating death) and shoots biomass was harvested and dried at 60 C for a few days before measuring shoot dry weight.

The fallow field experiments investigating preemergence and postemergence herbicides for control of glyphosate resistant Palmer amaranth were conducted at the University of Arizona studies in fallow fields. For the preemergence herbicide study, the field was listed, bed-shaped and standard small plot methods were used to establish a randomized complete block study with 4 replications (i.e., blocks). The herbicides Prowl H_2O (2 pt./A), Dual Magnum (1.33 pt./A), Caparol 4L (2.4 pt./A) and Diuron 80 WDG (1 lb/A) were applied to the beds using a tractor mounted plot sprayer and incorporated using a rolling cultivator. Following the rolling cultivator, Clarity (1 pt./A) and the above listed herbicide treatments were applied to other plots. The field was irrigated to incorporate and activate the herbicides and

to initiate Palmer amaranth germination, emergence and growth. Percent control was visually estimated and the number of emerged ivyleaf morningglory (*Ipomoea hederacea*) and Palmer amaranth on the bed tops were counted.

Results and Discussion

The growth inhibition measured in greenhouse assays of three Palmer amaranth seed collections in Buckeye, AZ compared to the known susceptible seed from Sahuarita, AZ found that two of the seed collections were resistant to glyphosate (Figure 1). The H & W and Buckeye seed collections were about 50 times more resistant to glyphosate than the susceptible Sahuarita seed collection. The original seed collection from 2012 in Buckeye (labelled Buckeye in the figures) was also found to be resistant to field rates of Staple herbicide (about 4X resistance) (Figure 2.)

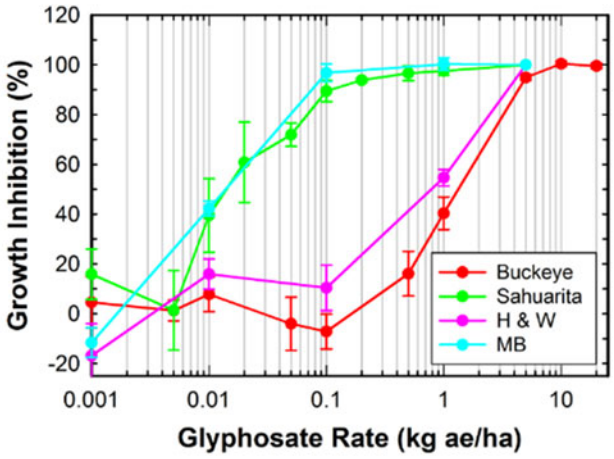

Figure 1. Growth inhibition based on shoot dry weight following treatment with glyphosate of three Buckeye, AZ locations and a susceptible biotype from Sahuarita, AZ. Data are means and standard errors.

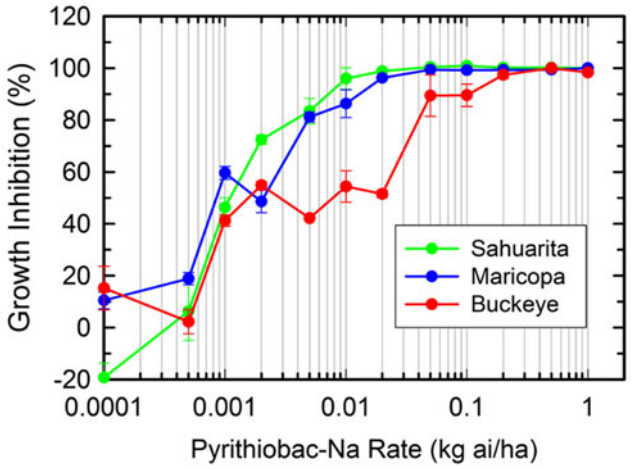

Figure 2. Growth inhibition based on shoot dry weight following treatment with Staple (pyrithiobac-Na) of the original 2012 Buckeye, AZ seed collection compared to susceptible biotypes from Maricopa and Sahuarita, AZ. Data are means and standard errors.

In contrast to the population collected in the Buckeye area, Palmer amaranth seed collected in alfalfa fields in San Tan Valley was resistant to Raptor (Figure 3) and Staple but was not resistant glyphosate (Figure 4). In 2014, many Palmer amaranth escapes were found in a cotton field in Marana, AZ following three applications of glyphosate at the maximum labelled rate for cotton. Seed was collected from plants on the field margins later in the year; greenhouse experiments will be conducted using these seed collections to look for glyphosate resistant individuals. Palmer escapes following glyphosate applications were also found in a pecan orchard in Red Rock, AZ and in corn field in Pearce, AZ but it is not clear that resistance is present. These population will be monitored in 2015.

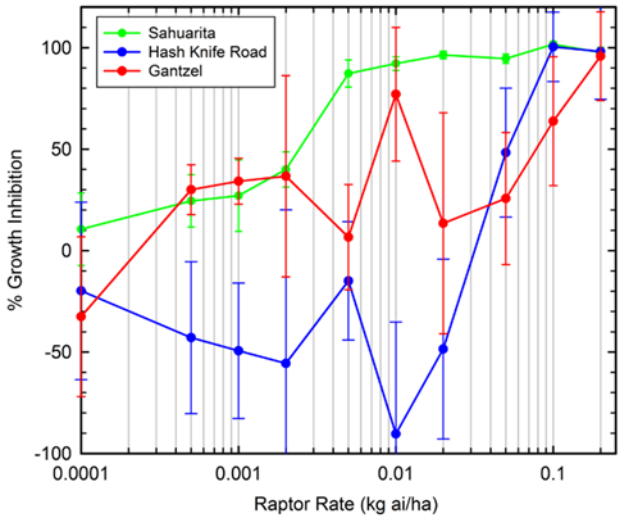

Figure 3. Growth inhibition based on shoot dry weight following treatment with Raptor (imazamox) of the two San Tan Valley seed collections from alfalfa fields compared to a susceptible biotype from Sahuarita, AZ. Data are means and standard errors.

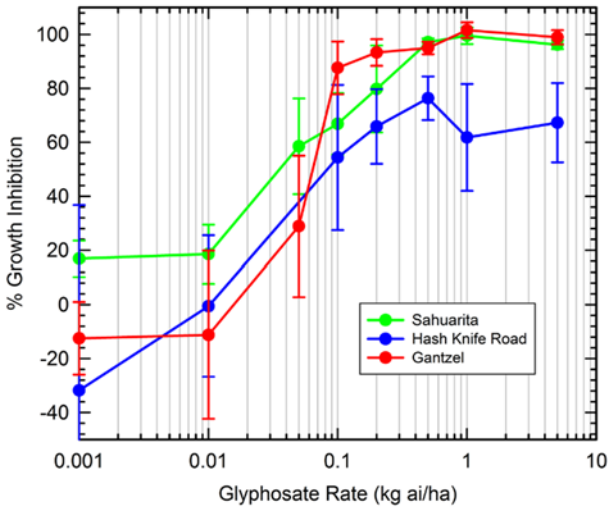

Figure 4. Growth inhibition based on shoot dry weight following treatment with glyphosate of the two San Tan Valley seed collections from alfalfa fields compared to a susceptible biotype from Sahuarita, AZ. Data are means and standard errors.

Field studies conducted at the University of Arizona Maricopa Agricultural Center on fallow cotton beds found that Prowl H_2O, Dual Magnum, Caparol 4L, Diuron 80 WDG and Clarity effectively suppressed Palmer amaranth emergence at 21 DAT compared to the untreated check (Table 1). Interestingly, Caparol and Diuron appeared to be more effected against Palmer amaranth when they were not incorporated with a rolling cultivator. Since Palmer amaranth seeds germinate close to the soil surface, using irrigation water to incorporate the herbicides may result in greater herbicide concentration in the zone of the soil profile where Palmer amaranth seeds germinate compared to potentially deeper incorporation with a rolling cultivator.

Table 1. Palmer amaranth emergence (plants per square foot) and percent control of ivyleaf morningglory and Palmer amaranth on fallow cotton beds following herbicide treatment. Data are means ± standard deviation of 4 replications. Means followed by the same letter within a column do not significantly differ (P = 0.05) according the Student-Newman-Keuls test.

Incorporation	Treatment	Rate	Percent Control		Palmer Amaranth
			Morningglory	Palmer Amaranth	(Plants/ ft^2)
Rolling Cultivator	Prowl H_2O	2 pt/A	13	86	2.4 b
	Dual Magnum	1.33 pt/A	9	93	0.3 c
	Caparol	2.4 pt/A	28	72	0.7 c
	Diuron	1 lb/A	34	81	5.7 b
Irrigation – every furrow	Prowl H_2O	2 pt/A	3	81	3.8 b
	Dual Magnum	1.33 pt/A	2	92	3 b
	Caparol	2.4 pt/A	69	99	0.1 c
	Diuron	1 lb/A	42	97	0.1 c
	Clarity	1 pt/A	27	96	0.4 c
Control	Untreated	No herbicide	0	0	40 a

Summary

Glyphosate-resistant Palmer amaranth was discovered in Buckeye, AZ in July 2012 after three 1.5 lb ae/A glyphosate applications failed to control Palmer amaranth plants. Seed were collected from mature female plants in the Buckeye field and subsequently many other areas of the state of Arizona. Glyphosate resistant Palmer amaranth in the original cotton field in Buckeye, AZ was highly resistant to glyphosate (50X resistance) and also resistant to Staple herbicide (4X resistance) in greenhouse studies conducted in 2013 and 2014. A population of Palmer amaranth in San Tan Valley, AZ was found to be moderately resistant to Raptor and Staple but susceptible to glyphosate. Palmer amaranth plants in Marana, AZ escaped three applications glyphosate at the maximum labelled rate. The range of glyphosate symptoms expressed by escaped plant indicated the development of resistance in this population. Two other locations in Arizona, Red Rock and Pearce, AZ also have populations of Palmer amaranth that escaped glyphosate treatment but more seed collections and greenhouse experiments are needed to confirm resistance. Field studies on fallow cotton beds with Prowl H_2O (2 pt./A), Dual Magnum (1.33 pt./A), Caparol 4L (2.4 pt./A) and Diuron 80 WDG (1 lb/A) found that these herbicides were highly effective in suppressing Palmer amaranth germination, emergence and growth 21 DAT. Thus, the use of preemergence herbicides can be an effective way to diversify herbicide mechanisms of action used in Arizona cotton fields.

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